Appendix B

Crater Analysis and Reporting

Although greater reliance should be placed on reports from trained teams, all personnel should know how to analyze craters and make the proper report. Since crater analysis teams are not authorized by TOE, each unit (including units normally located in rear areas) should select and train at least one team of two or three members. To adequately support their maneuver unit, fire support personnel must know how to analyze and report crater information.

GUN AND HOWITZER SHELL CRATER ANALYSIS

The projectile direction of flight can be determined fairly accurately from the projectile crater or ricochet furrow. It is possible to obtain, the azimuth of a ray that will pass through or near the enemy position by accurately locating the crater and determining the direction of flight. While it is possible to determine the direction to the firing weapons from one crater or ricochet furrow, an enemy firing unit may be located by plotting the intersection of the average azimuths from at least three widely separated groups of craters.

In crater analysis, differences in angle of fall, projectile burst patterns, directions of flight, and time fuze setting will help distinguish between enemy weapons firing on a given area.

Refer to FM 3-3 for guidance on friendly troop safety from the effects of craters contaminated with chemical agents. Refer to FM 3-3 also for guidance in marking craters containing chemical, biological, or radiological contamination.

VALUE OF ANALYSIS

By analyzing shell craters, the crater analysis team can:

- Verify, as confirmed locations, suspected locations that have been obtained by other means.
- Confirm the presence of enemy artillery, rockets, or mortars and obtain an approximate direction to them.
- Detect the presence of new types of enemy weapons, new calibers, or new ammunition manufacturing methods.

INSPECTION OF SHELLED AREAS

Shelled areas must be inspected as soon as possible after the shelling. Craters that are exposed to the elements or are abused by personnel deteriorate rapidly and thereby lose their value as a source of information.

SURVEY OR CRATER LOCATION

Areas must be located accurately enough for plotting on charts, maps, or aerial photographs. Deliberate survey is not essential; hasty survey techniques or map spotting will usually suffice. Direction can be determined by use of an aiming circle or a compass.

DETERMINATION OF DIRECTION

PATTERN

A clear pattern produced on the ground by a detonating shell indicates the direction from which the shell came.

FACTORS AFFECTING PATTERN

Because of terrain irregularities and soil conditions, typical shell crater patterns are the exception, not the rule. Side spray marks are a principal part of the pattern caused by fragmentation. Base spray is negligible from gun and howitzer projectiles but is appreciable from mortars. The width, angle, and density of the side spray pattern vary with the projectile, angle of impact, type of fuze, terminal velocity of the projectile, and soil composition.

In determining direction, the following must be considered:

- Effect of stones, vegetation, stumps, and roots in the path of the projectiles.
- Variations in density and type of soil.
- The slope of the terrain at the point of impact.

From any group, only the most clearly defined and typical craters are used.

MARKS ON VEGETATION AND OTHER OBJECTS

Marks made by a round as it passes through trees, snow, and walls often indicate the direction from which the round was fired. The possible deflection of the shell upon impact with these objects must be considered. Evidence of such deflection should not be overlooked.

DRIFT AND WIND EFFECTS

Drift and lateral wind effects do not materially change the direction of the shell axis during flight.

RICOCHET FURROWS

Often, when an artillery round with a delay fuze is fired at low angle, it bounces or ricochets from the surface of the earth. In doing so, it creates a groove, which is called a ricochet furrow. This groove is an extension of the direction of fire. Care must be taken, however, to determine that the shell was not deflected before or while it was making the furrow.

CRATER ANALYSIS

The initial step in crater analysis is to locate a usable crater for use in determining the direction to the hostile weapon. The crater should be reasonably fresh and clearly defined on the ground. Since the crater is the beginning point for plotting the direction to the enemy weapon, the grid coordinates of the crater should be determined as precisely as time and the method used will allow. The direction to the firing weapon must be determined by one of the methods described below, depending on the angle of the trajectory and type of fuze fired. Shell fragments must be collected for use in identifying the type and caliber of the weapon.

LOW-ANGLE FUZE QUICK CRATERS (ARTILLERY)

The detonation of a low-angle fuze quick projectile causes an inner crater. The burst and momentum of the shell carry the effect forward and to the sides, forming an arrow that points to the rear (toward the weapon from which the round was fired). The fuze continues along the line of flight, creating a fuze furrow. There are two methods of obtaining a direction to a hostile weapon from this type of crater. These are the fuze furrow and center of crater method and the side spray method. The best results are obtained by determining a mean, or average, of several directions obtained by using both methods.

FUZE FURROW AND CENTER OF CRATER METHOD

In the fuze furrow and center of crater method, one stake is placed in the center of the crater and another is placed in the furrow at the point where the fuze was blown forward to the front of the crater. A direction-measuring instrument is set up in line with the two stakes, and the direction to the hostile weapon is measured. A variation of this method is to place a stake where the shell entered the ground instead of in the fuze furrow and determine the direction in the same manner. This variation method is rarely possible since the explosion of the shell usually destroys indications of the point of entry. The five steps of the fuze furrow and center of crater methods are as follows:

- Place a stake in the center of the crater.
- Place a second stake in the fuze furrow.
- Set up a direction-measuring instrument in line with the stakes and away from fragments.
- Orient the instrument.
- Measure the direction to the hostile weapon.

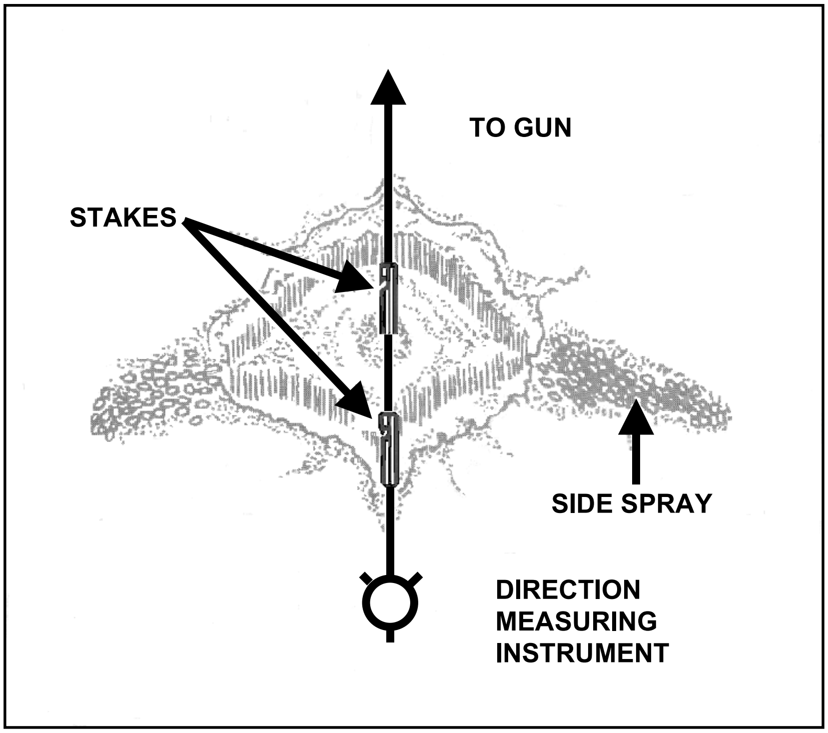


Figure B-1. Fuze Furrow and Center of Crater Method

SIDE SPRAY METHOD

Another method used to measure the direction to a hostile weapon is to bisect the angle formed by the lines of side spray. The seven steps in measuring the direction of a fuze quick crater by the side spray method are as follows:

- Place a stake in the center of the crater.
- Place two stakes, one at the end of each line of side spray, equal distant from the center stake.
- Hold a length of communications wire (or another appropriate field-expedient means) to each side spray stake, and strike an arc forward of the fuze furrow.
- Place a stake where these arcs intersect.
- Set up a direction-measuring instrument in line with the center stake and the stake at the intersection of the arcs.
- Orient the instrument.
- Measure the direction to the firing weapon.

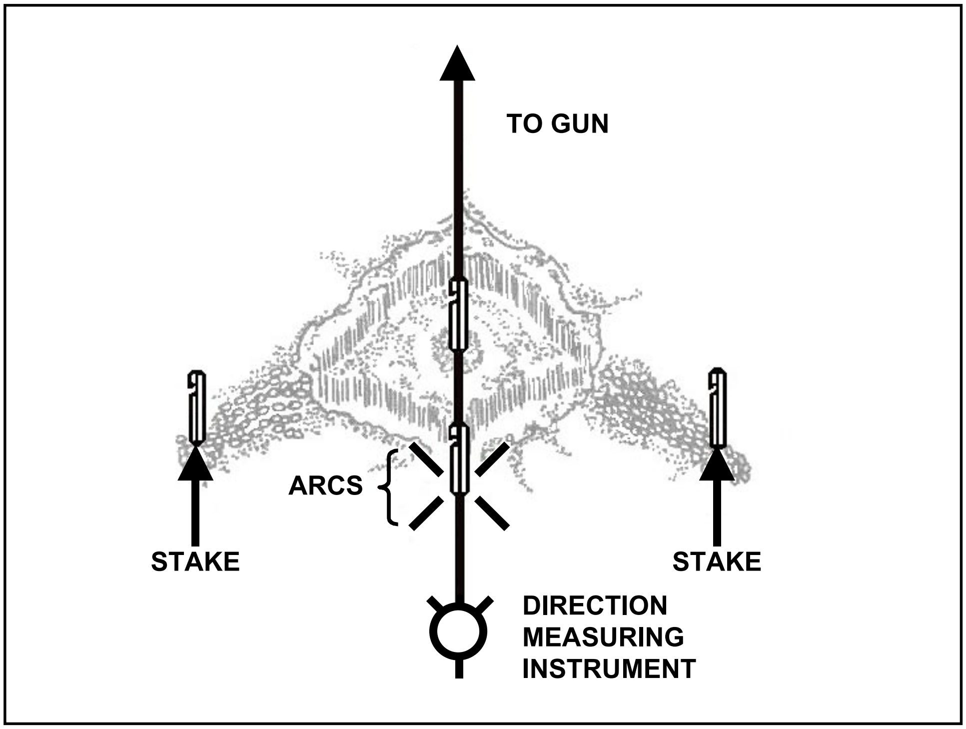


Figure B-2. Side Spray Method

LOW-ANGLE FUZE DELAY CRATERS (ARTILLERY)

There are two types of low-angle fuze delay craters - ricochet and mine action.

RICOCHET CRATERS

The projectile enters the ground in a line following the trajectory and continues in a straight line for a few feet, causing a ricochet furrow. The projectile then normally deflects upward and at the same time changes direction. The change of direction usually is to the right as the result of the spin, or rotation, of the projectile. The effect of the airburst can be noted on the ground. Directions obtained from ricochet craters are considered to be the most reliable. The five steps required to determine direction from a ricochet furrow are as follows:

- Clean out the furrow.
- Place a stake at each end of a usable straight section of the furrow.
- Set up a direction-measuring instrument in line with the stakes and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

MINE ACTION CRATER

Mine action occurs when a shell bursts beneath the ground. Occasionally, such a burst will leave a furrow that can be analyzed in the same manner as the ricochet furrow. A mine action crater that does not have a furrow cannot be used to determine the direction to the weapon.

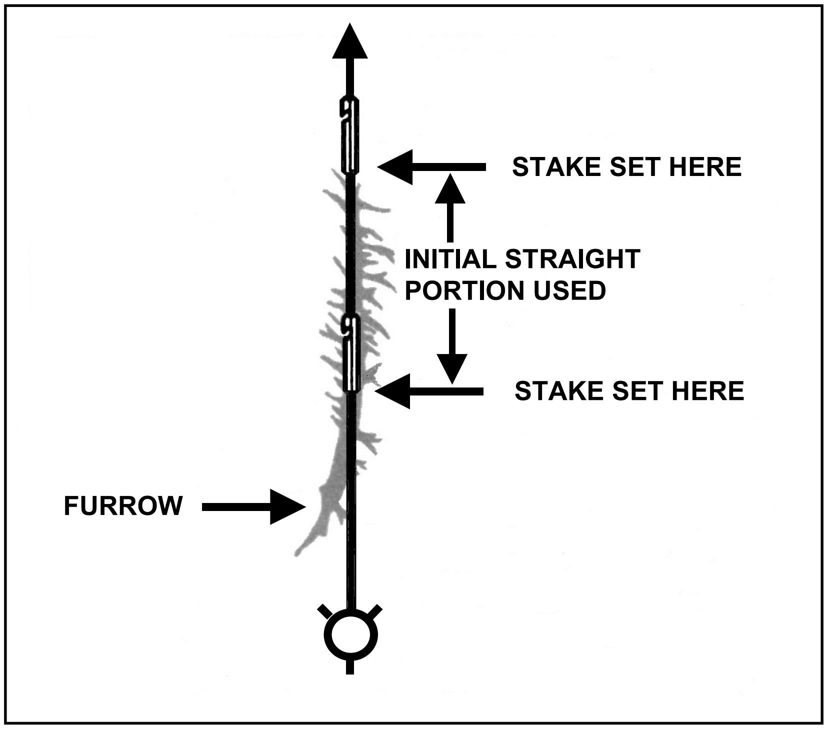


Figure B-3. Ricochet Furrow Method

HIGH-ANGLE SHELL CRATERS (MORTARS)

In a typical high-angle mortar crater, the turf at the forward edge (the direction away from the hostile mortar) is undercut. The rear edge of the crater is shorn of vegetation and grooved by splinters. When fresh, the crater is covered with loose earth, which must be carefully removed to disclose the firm burnt inner crater. The ground surrounding the crater is streaked by splinter grooves that radiate from the point of detonation. The ends of the splinter grooves on the rearward side are on an approximately straight line. This line is perpendicular to the horizontal trajectory of the round. A fuze tunnel is caused by the fuze burying itself at the bottom of the inner crater in front of the point of detonation. Three methods may be used to determine direction from a high-angle mortar shell crater-main axis, splinter groove, and fuze tunnel.

MAIN AXIS METHOD

The four steps used to determine direction by the main axis method are as follows:

- Lay a stake along the main axis of the crater, dividing the crater into symmetrical halves. The stake points in the direction of the mortar.
- Set up a direction-measuring instrument in line with the stake and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

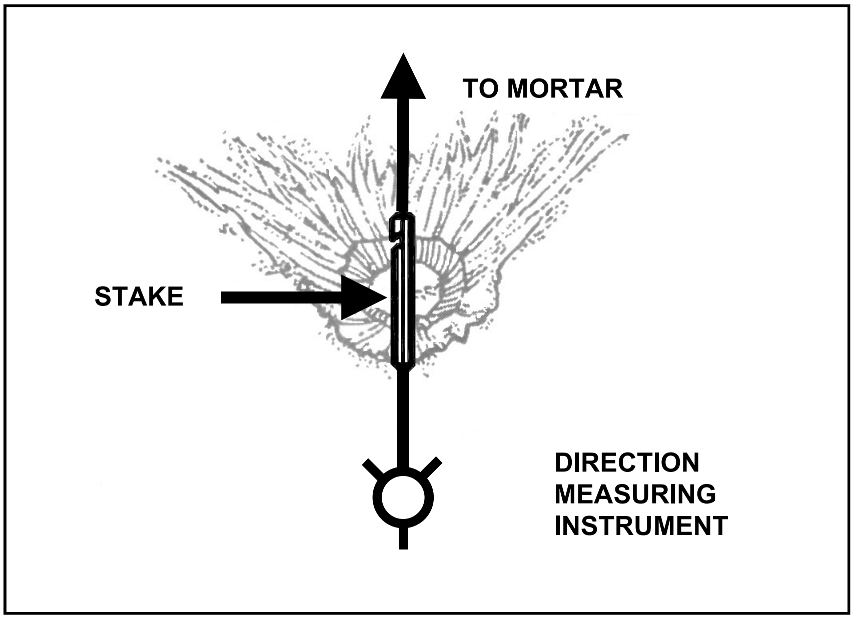


Figure B-4. Main Axis Method

SPLINTER GROOVE METHOD

The five steps used to determine direction by the splinter groove method are:

- Lay a stake along the ends of the splinter grooves that extend from the crater.
- Lay a second stake perpendicular to the first stake through the axis of the fuze tunnel.
- Set up a direction-measuring instrument in line with the second stake and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

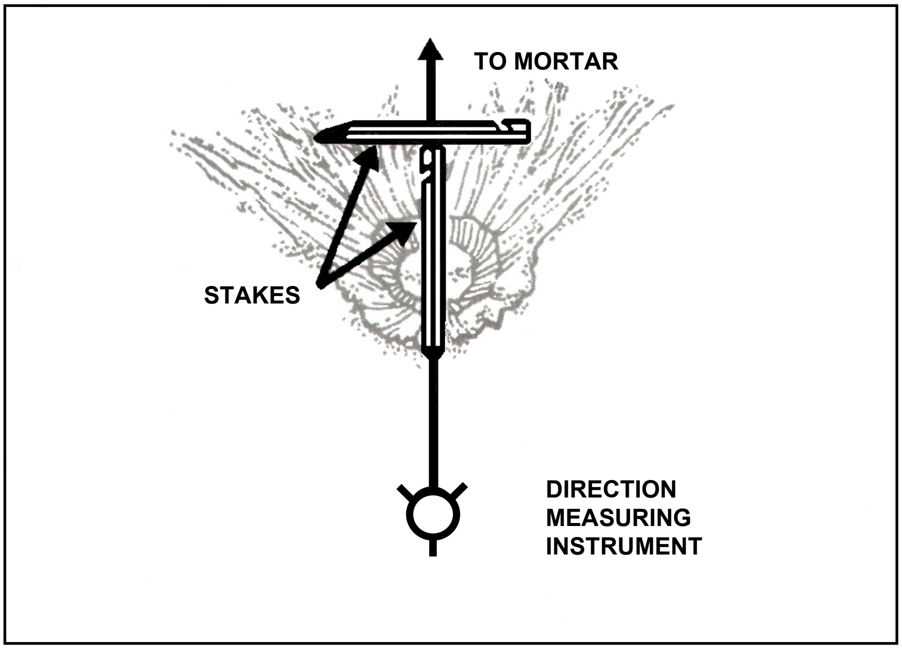


Figure B-5. Splinter Groove Method

FUZE TUNNEL METHOD

The four steps used to determine direction by the fuze tunnel method are:

- Place a stake in the fuze tunnel.
- Set up a direction-measuring instrument in line with the stake and away from fragments.
- Orient the instrument.
- Measure the direction to the weapon.

Note: If the angle of fall is too great (a 90 degree angle), the fuze tunnel method cannot be used.

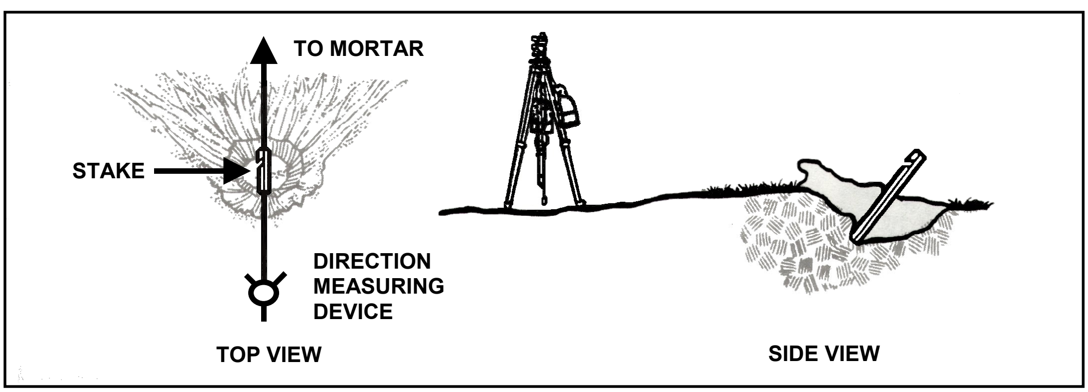


Figure B-6. Fuze Tunnel Method

ROCKET CRATERS

A rocket crater resulting from a rocket impacting with a low or medium angle of fall is analyzed in the same manner as an artillery crater resulting from a projectile armed with fuze quick. However, if the rocket impacts with a high angle of fall, the crater is analyzed in the same manner as a crater resulting from a mortar round fired with fuze quick. (See paragraph on low-angle fuze quick craters.) The tail fins, rocket motor, body, and other parts of the rocket may be used to determine the caliber and type of rocket fired.

SHELL FRAGMENT ANALYSIS

Identification by weapon type and caliber may be determined from shell fragments found in shell craters. Dimensions of the parts, as well as those of the complete shell, vary according to the caliber and type of shell.

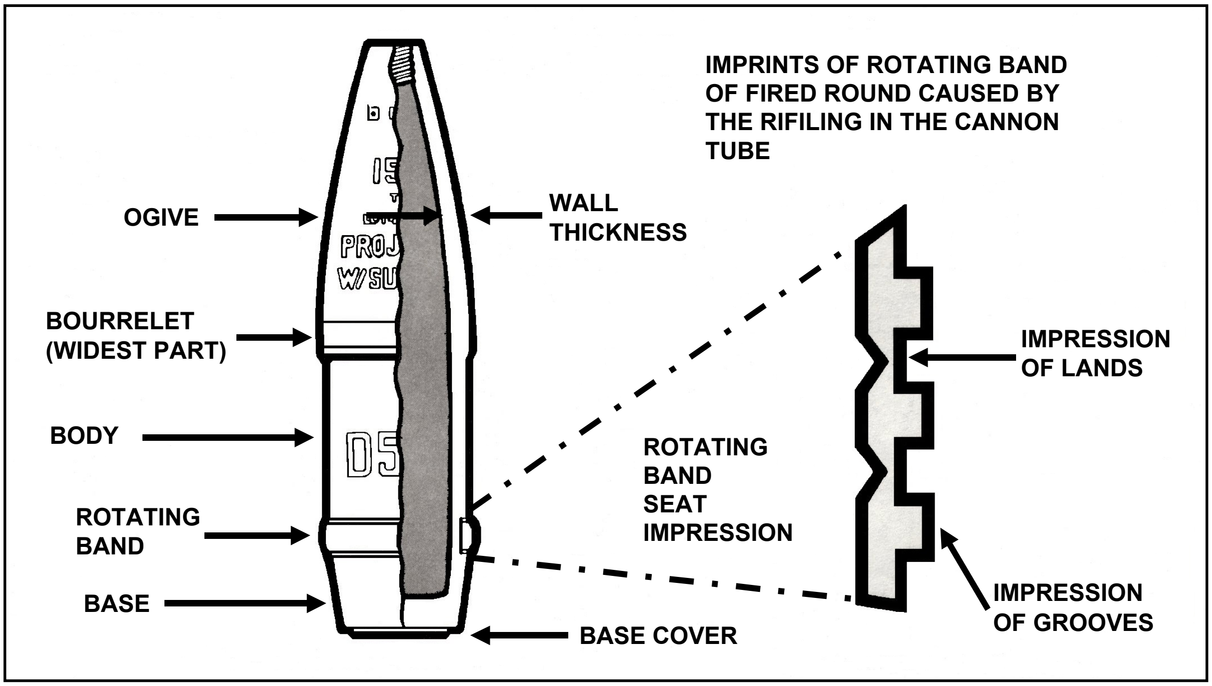


Figure B-7. Typical Shell

DUDS AND LOW-ORDER BURSTS

The most logical means of identifying the caliber of a projectile is to inspect a dud of that caliber. However, since a dud may not always be available or may be too dangerous to handle, a low-order burst is the next best means of identification. When the explosive filler is not completely detonated, a low-order burst occurs and large shell fragments result. Such large pieces can be used to identify thread count, curvature, wall thickness, and so forth.

HIGH-ORDER BURSTS

A high-order burst normally results in small-deformed fragments. These fragments are useless for identification purposes unless they include a section of either the rotating band or the rotating band seat. Fragments of either of these sections positively identify the shell, since each shell has its own distinctive rotating band markings.

ROTATING BANDS AND BAND SEATS

A shell may be identified as to caliber, type, and nation of origin from the:

- Pattern or rifling imprints on rotating bands.
- Width, number, and size of rotating bands.
- Dimensions and pattern of keying or knurling on the rotating band seat.
- Dimensions and pattern of rotating band seat keying and knurling impressed on the rotating band.

US and former Soviet block artillery require a rotating band or band seat for spin-stabilized projectiles. Except for the rotating bands and band seats of the tail fins, different types of shells may be identical in one or more dimension (such as wall thickness). However, shells are seldom alike in two or more dimensions. Therefore, it is necessary to obtain shell fragments from two or more dimensions to make a positive identification. For a discussion of interior ballistics and how rifling imprints are made on rounds as they are fired, see FM 3-09.40 (6-40).

TAIL FINS

A mortar can be identified from the tail fins. Tail fins often are found in the fuze tunnel of the crater. A mortar that is not fin-stabilized may be identified from the pieces of the projectile on which the rifling is imprinted.

FUZES

Since the same type of fuze may be used with several different calibers or types of projectiles, it is impossible to establish the type and caliber of a weapon by this means.

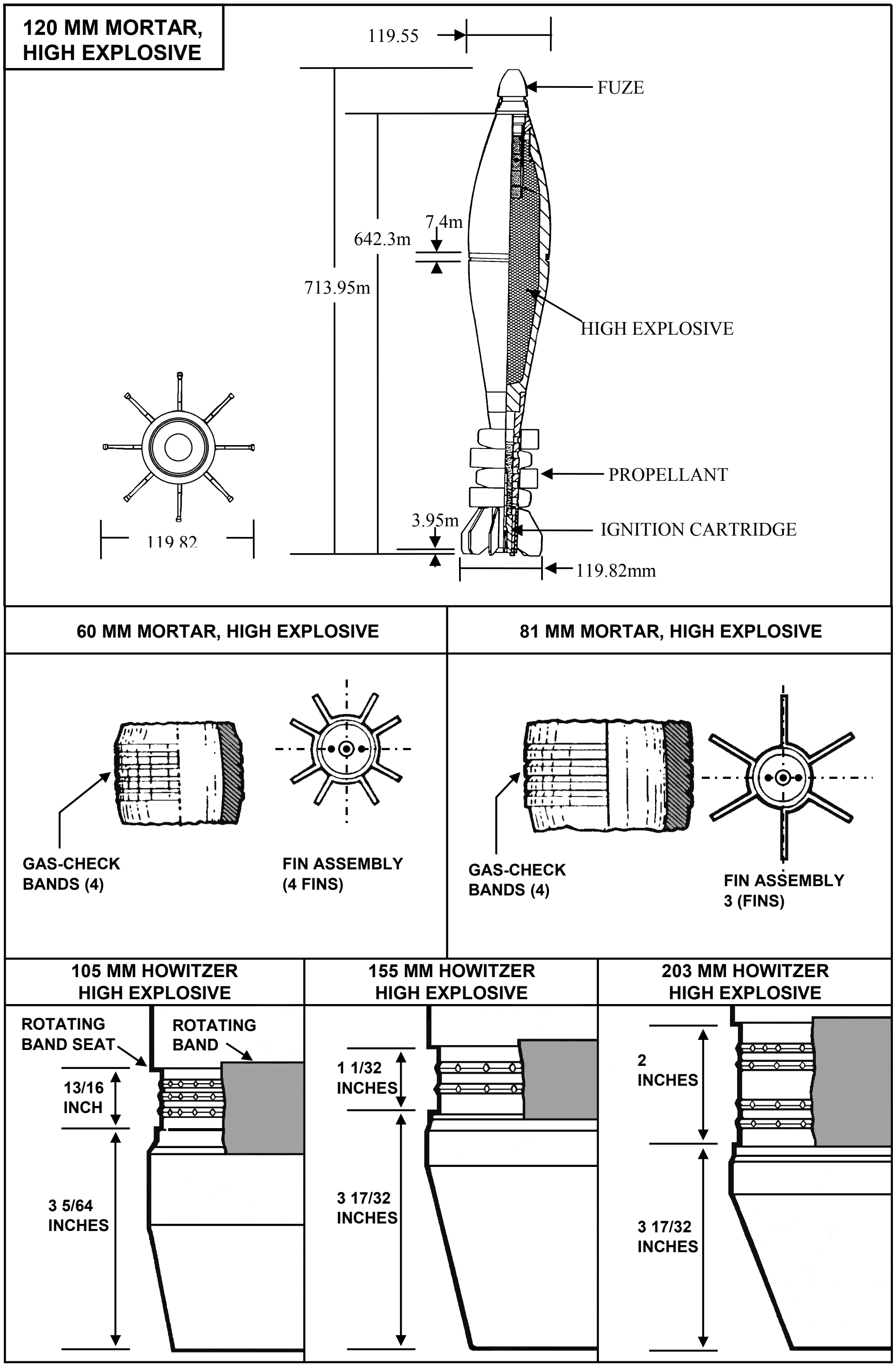
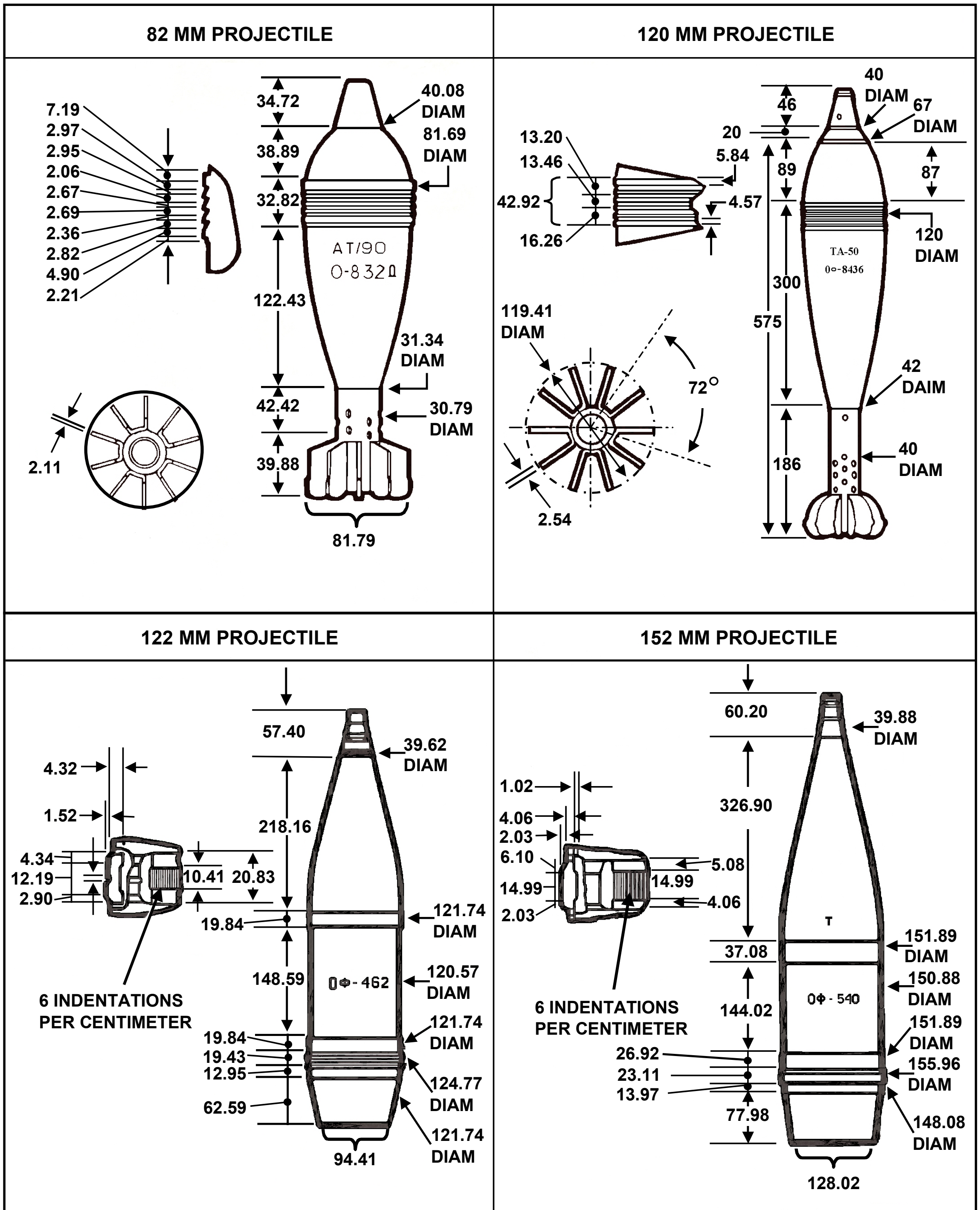


Figure B-8. Shell Fragment and Tail Fin Identification of US Ammunition



NOTE: All dimensions in millimeters. To convert to inches, multiply millimeters by 0.03937.
LEGEND: DIAM = diameter

Figure B-9. Ammunition Available to Potential Enemies

This section implements STANAG 2008, Edition 6, and QSTAG 503, Edition 1.

SHELLING REPORTS

The division artillery is responsible for counterfire. Therefore, bombing reports (BOMREPs), SHELREPs, MORTREPs, and rocketing reports (ROCKREPs) should be forwarded as quickly as possible to the DIVARTY TOC or the designated counterfire headquarters through either fire direction or fire support channels. If a DS battalion receives a report and that battalion decides to attack a target developed from it, the report of action taken and a target damage assessment, if available, should be forwarded to the DIVARTY TOC or designated counterfire headquarters when the action is completed. Shelling reports are forwarded manually using the artillery counterfire information form or by using the target indicator processing functions contained in AFATDS. See Appendix A for a detailed discussion of AFATDS procedures.

ARTILLERY COUNTERFIRE INFORMATION FORM

The information obtained from a crater should be forwarded by the most rapid available means in the format of DA Form 2185-R. The artillery counterfire information form standardizes reporting procedures and complies with STANAG 2008 and QSTAG 503. No matter how little information has been obtained, do not hesitate to forward the information. Fragmentary or incomplete information (a radio or telephone report) is often of value in supplementing or confirming existing information. This radio or telephone report may be followed by a written report on DA Form 2185-R.

Any usable fragments obtained from crater analysis should be tagged and sent to the battalion S2. As a minimum, the tag should include the following information:

- Location of the crater.
- Direction to the hostile weapon.
- Date-time group of the shelling.

The DS artillery S2 forwards the information contained in a SHELREP to the counterfire officer (CFO) at the designated counterfire headquarters. The CFO plots the location of the crater and a line representing the direction measured to the weapon on a SHELREP overlay. He compares the information with that received from other sources and tries to locate enemy weapons from the intersections of direction lines to weapons of the same caliber.

EXAMPLE

The information in the following situation is illustrated on the completed DA Form 2185-R in Figure B-10. You are the executive officer of Battery A, 1st Battalion, 30th Field Artillery, located at grid NP392841. Your call sign is A3F22. At 0545, the enemy shelled your position for 2 minutes with a total of eight rounds of high explosive (HE). The tempo and pattern of bursts suggest an enemy four-gun battery. Your battery commander believes that the enemy intent is harassment. Your SHELREP team determines the direction to the enemy battery to be 4,810 mils. The team also located a fragment that includes a part of the rotating band seat. The shell was identified as an enemy 122-mm howitzer projectile.

The SHELREP team makes entries on the DA Form 2185-R. However, personnel do not complete the four blanks in the heading of the form. (The receiving agency completes these blanks; for example, the battalion S2 section.)

The information contained in Columns B and K of Section I is encoded for security reasons. The current call sign or code name for the unit is entered in Column A. Column B is not applicable when this form is used for crater analysis.

Sections II and III are completed in the target production section of the DIVARTY TOC.

ARTILLERY COUNTERFIRE INFORMATION

(For use of this form, see FM 6-121; the proponent agency is TRADOC.)

RECEIVED BY	FROM	TIME	NUMBER

SECTION I – BOMBER, SHELREP, MORTREP, OR ROCKREP (Cross out items not applicable.)

UNIT OF ORIGIN (Current call sign address group or code name)	POSITION OF OBSERVER (Encode if HQ or important OP or if Column F gives info on location)	DIRECTION (Grid bearing of FLASH, SOUND, or GROOVE of SHELL [state which] in mils unless otherwise stated). (Omit for aircraft)	TIME FROM	TIME TO	AREA BOMBED, SHELLED, OR MORTARED (Grid ref [in clear] or grid bearing to impact in mils and distance from observer in meters [encoded]) (Dimension of the area in meters) by (the radius) or (length and width)	NUMBER AND NATURE OF GUNS (Mortars, rocket launchers, aircraft or other methods of delivery)	NATURE OF FIRE (Adjustment, fire for effect, or harassing) (May be omitted for aircraft)	NUMBER, TYPE, AND CALIBER (State whether measured or assumed) OF SHELLS, ROCKETS (or MISSILES), AND BOMBS measured	TIME OF FLASH-TO-BANG (Omit for aircraft)	DAMAGE (Encode if required)
F22	NA	4810m	0545	0547	392841	4 ARTY	H	8 HE 122	NA	NA
A	B	C	D	E	F	G	H	I	J	K

	SECTION II – LOCATION REPORT						SECTION III – COUNTERFIRE ACTION		
REMARKS	SERIAL NUMBER (Each location that is produced by a locating unit is given a serial number)	TARGET NUMBER (If the weapon or activity has previously been given a target number, it will be entered here)	POSITON OF TARGET (The grid reference or grid bearing and distance of the located weapon or activity)	ACCURACY (The accuracy to which the weapon was located. CEP in meters and the means of location if possible)	TIME OF LOCATION (Actual time the location was made)	TARGET DESCRIPTION (Dimensions if possible): 1. Radius of target 2. Target length and width in meters	TIME FIRED (Against hostile target)	FIRED BY	NUMBER OF ROUNDS, TYPE OF FUZE, AND PROJECTILES
L	M	N	P	Q	R	S	T	U	V

DA FORM 2185-R, 1 APR 90 (Conforms with STANAG 2008) Edition of 1 May 78 is obsolete

Figure B-10. Artillery Counterfire Information Form

EQUIPMENT

Three elements - direction, dimensions, and curvature - must be measured for crater analysis. The equipment used by the crater analysis team should consist of the following items:

- Aiming circle (M2 compass), stakes, and communications wire to obtain the direction from the crater to the weapon that fired the projectile.

- A curvature template to measure the curvature of the fragment to determine the caliber of the shell. The template can be constructed of heavy cardboard, acetate, wood, or other appropriate material.
- Defense Intelligence Agency Projectile Fragment Identification Guide for measuring fragment dimensions (DST-1160-G-029-85, with Change 1, dated 27 Jan 89).

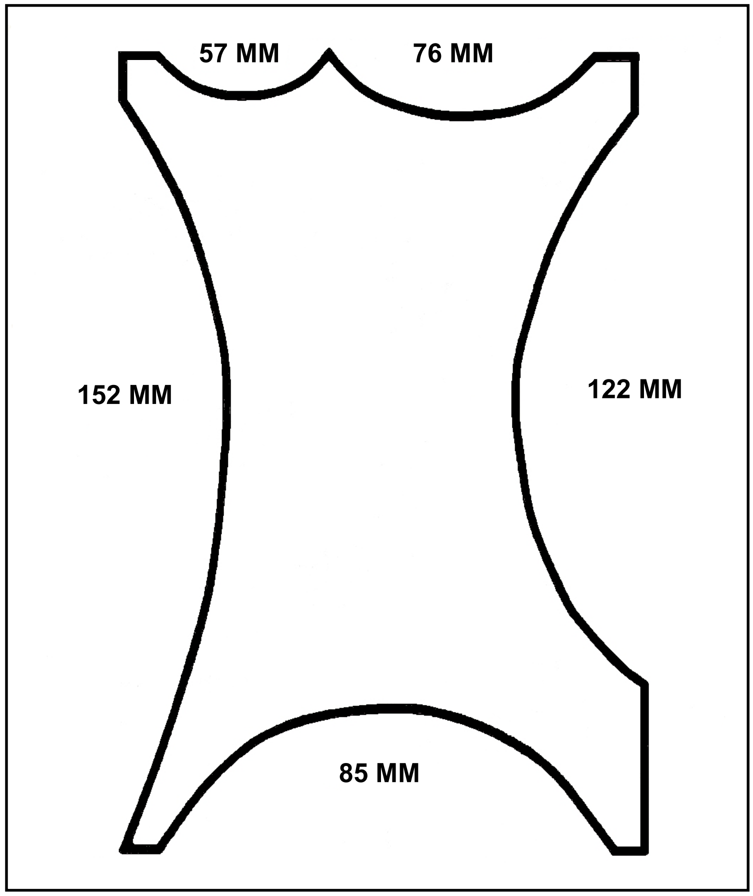


Figure B.12 Curvature Template